

Dust Storms and Water Ice Clouds: Feature Detection for use Onboard THEMIS

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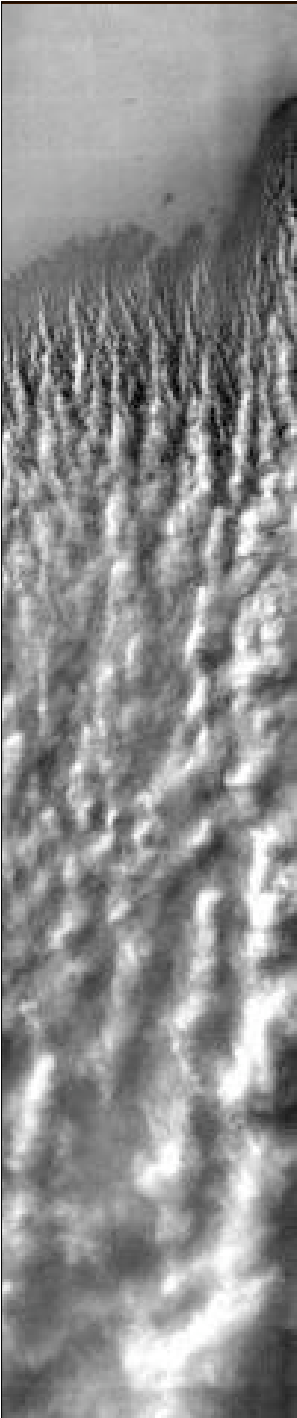
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National Aeronautics and
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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Goal

- Estimate aerosols in Martian atmosphere from Mars orbit
 - Dust optical depth
 - Water ice cloud optical depth
- Why aerosols?
 - Enhance understanding of Martian atmosphere
 - Monitoring for aerobraking
 - Why from orbit?
 - Limited bandwidth: can't transmit all possible observations
 - Automated detection of features of interest



THEMIS image
V08874006

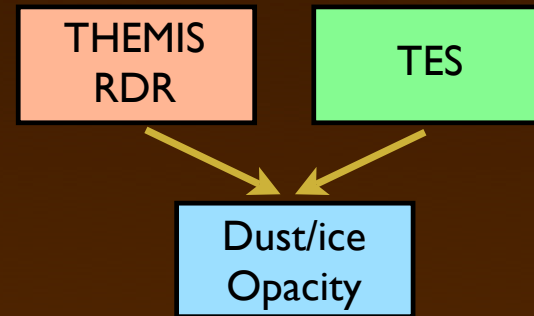
THEMIS

- VIS/IR camera onboard Mars Odyssey
- IR instrument
 - 10 bands
 - 6.78-14.88 microns
 - 100-m resolution
 - Data collection since February 2002
 -
- How accurately can we estimate opacity using uncalibrated data?



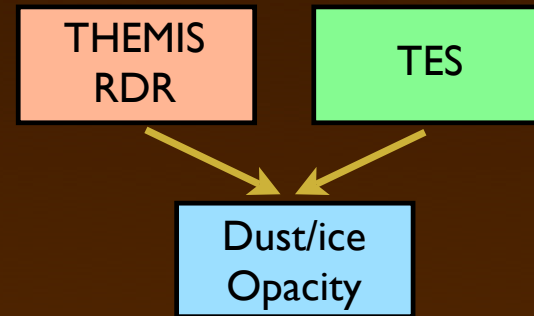
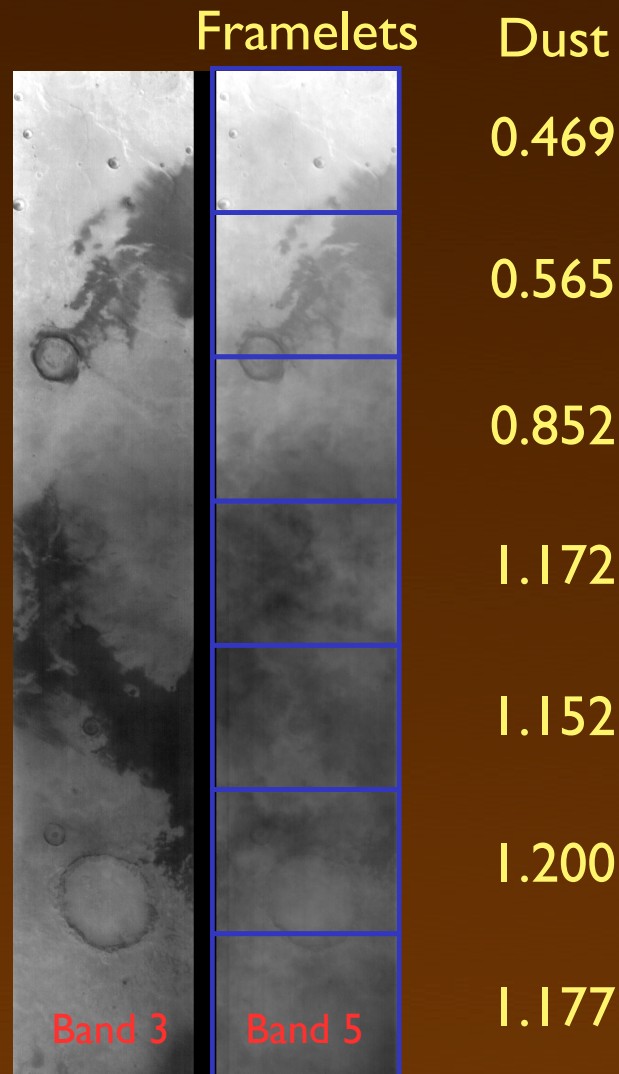
Estimating Martian Aerosols

- Smith et al. (2003)
 - THEMIS RDR (calibrated)
 - TES (surface emissivity and atmospheric temp. profile)
 - Iterative least-squares to obtain dust and ice opacities

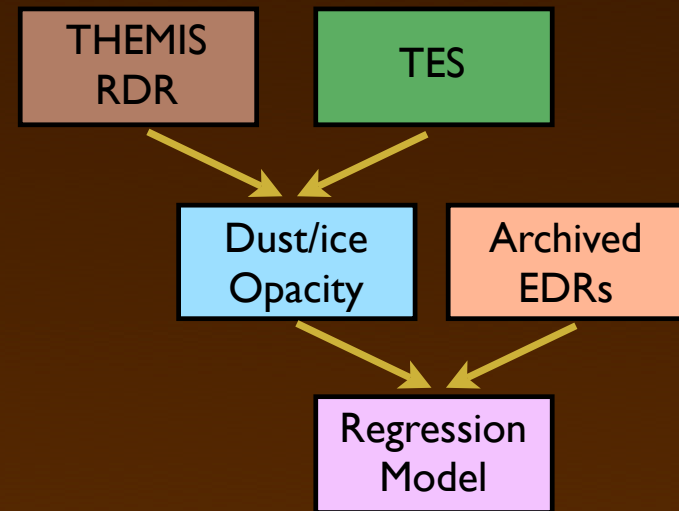


Estimating Martian Aerosols

- Smith et al. (2003)



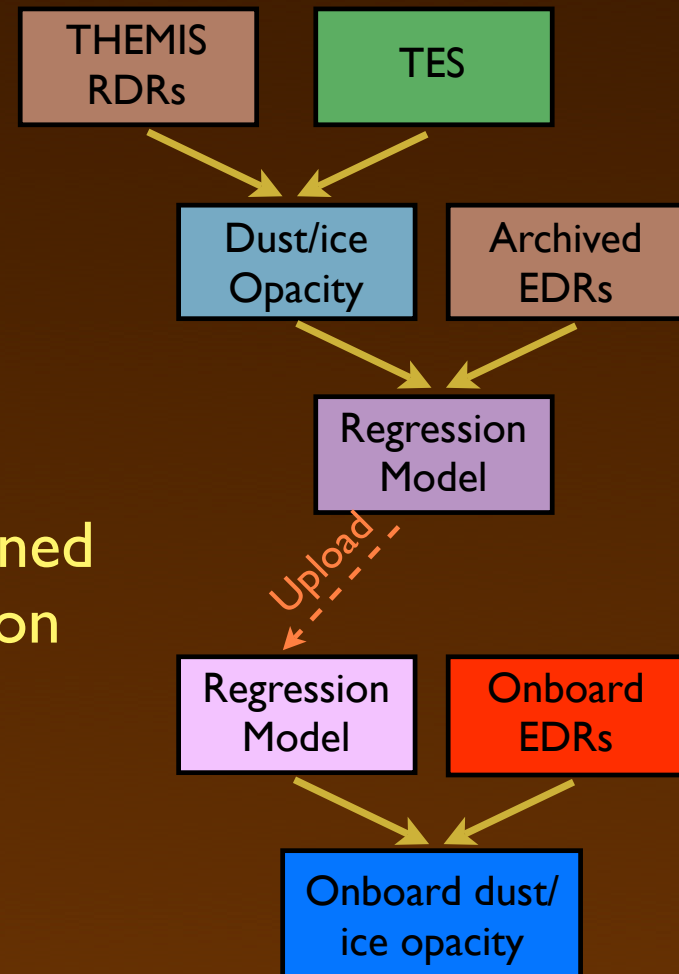
Estimating Martian Aerosols



- Onboard approach
 - THEMIS EDR + model trained to predict opacities based on Smith et al. values

Estimating Martian Aerosols

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Regression Models

- $$\tau' = \beta + \sum_{b=2}^9 w_b \times T_b$$

Predicted opacity Weights EDR values

- Linear least-squares

Objective functions:

$$\sum_i (\tau_i - \tau'_i)^2$$

- Linear SVM: fast
- Gaussian SVM: slower, more accurate

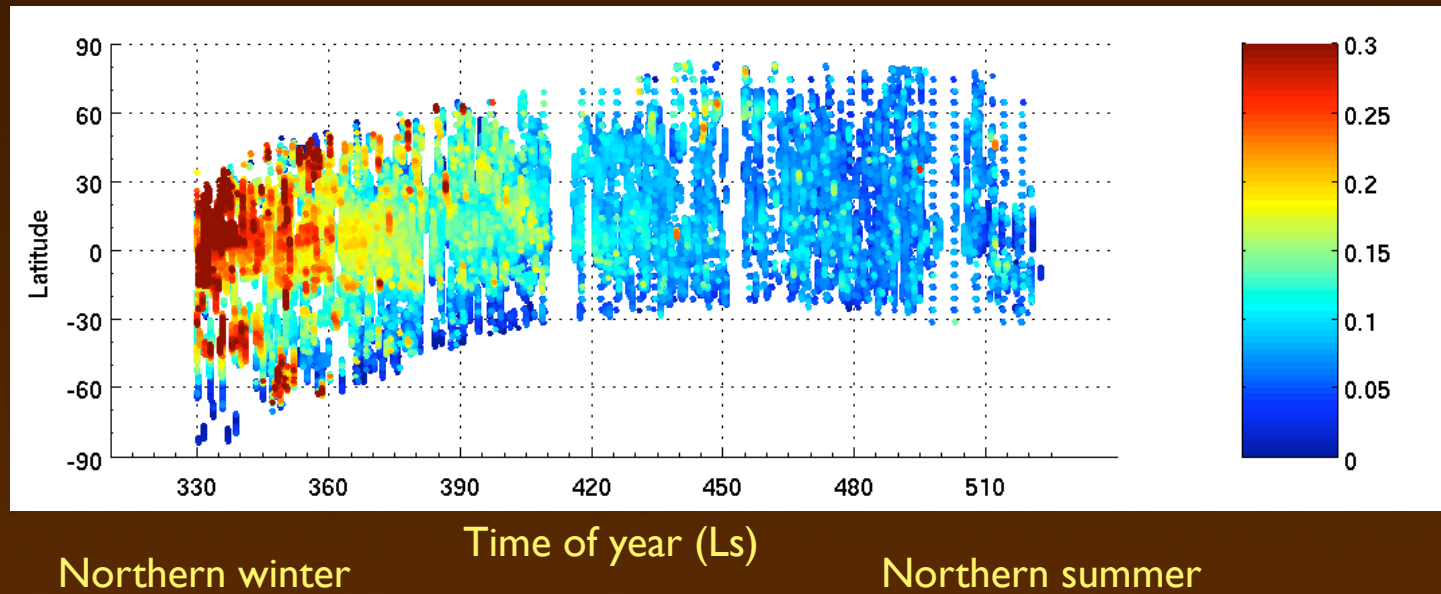
$$\frac{1}{2} ||w||^2 + C \sum_i (\max(|\tau_i - \tau'_i| - \epsilon, 0))$$

Regularization Error tolerance

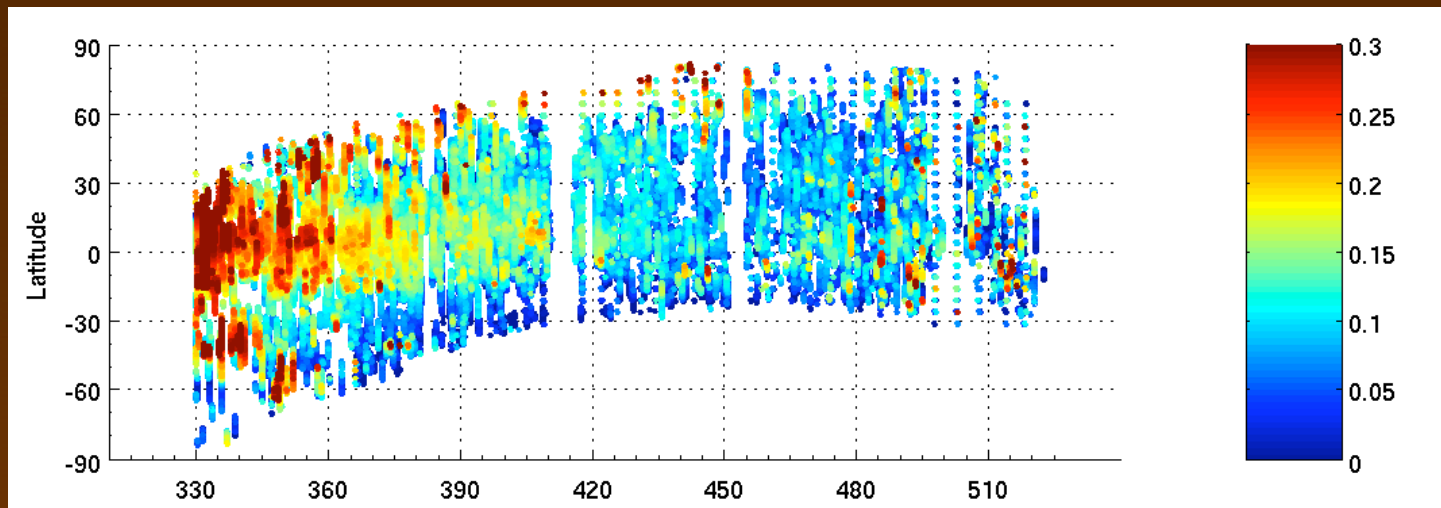
This study:
C = 50, epsilon = 0.01

Results: Dust Opacity

Our
Results

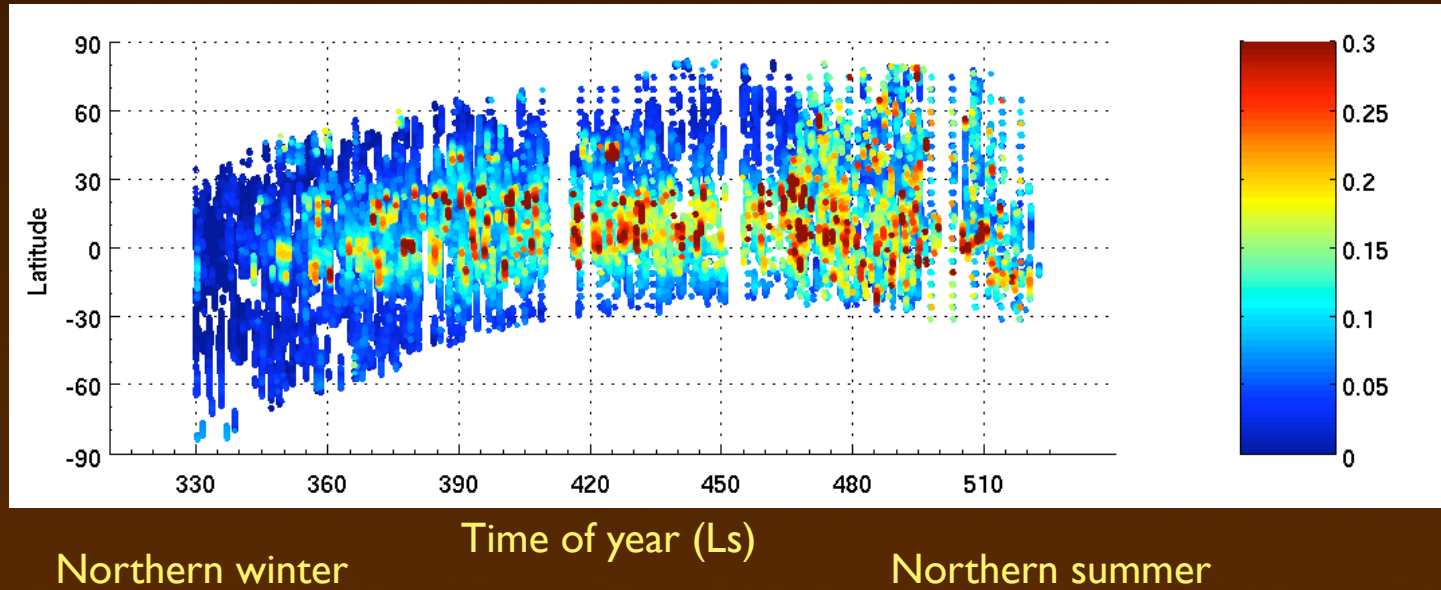


Smith et al. (2003)
Results

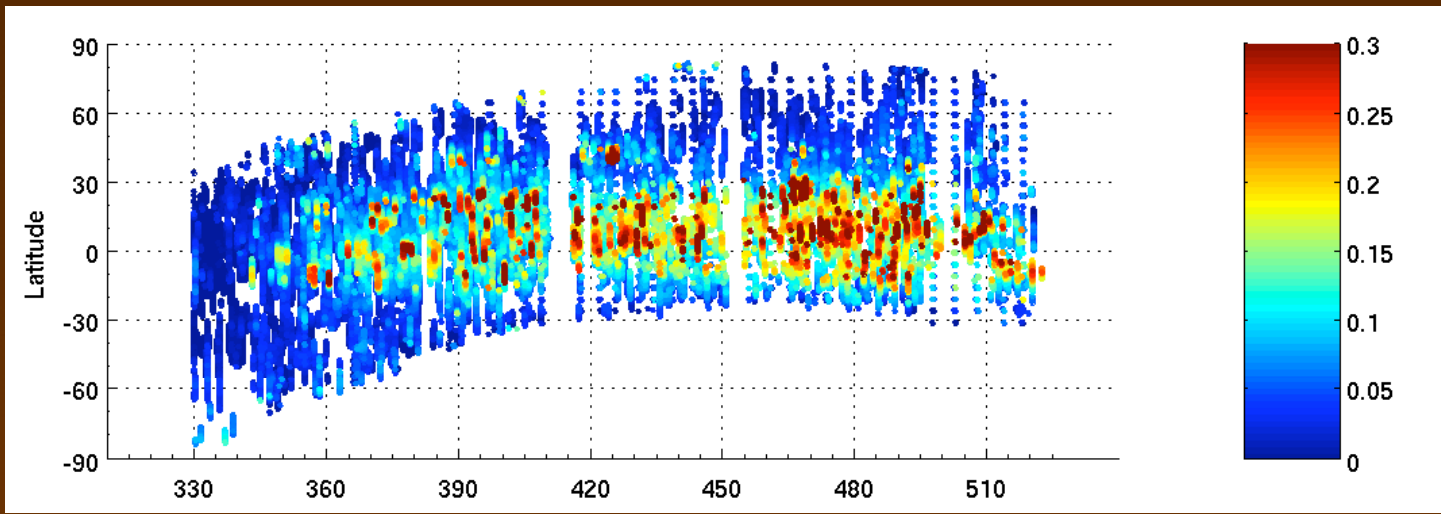


Results: Water Ice Clouds

Our
Results



Smith et al. (2003)
Results



Results

- Train model on 1440 framelets (every 50th)
- Evaluate model on all 72,061 framelets

| Regression method | Dust | | Ice | |
|----------------------|-------|-------|-------|-------|
| | RMSE | Merr | RMSE | Merr |
| Linear least squares | 0.043 | 0.031 | 0.037 | 0.022 |
| Linear SVM | 0.044 | 0.032 | 0.037 | 0.023 |
| Gaussian SVM | 0.037 | 0.025 | 0.036 | 0.017 |

- Uncertainty reported by Smith et al.
 - ~0.04 or 10% of total optical depth
- Note: NOT a replacement for RDR analysis!

Conclusions

- Onboard monitoring of Martian atmosphere is feasible, if trained on true values on the ground
- In progress:
 - Obtain results for all THEMIS data to date
 - Evaluate computational cost of each model
- Thanks to:
 - Nghia Tang
 - THEMIS Team